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STRIÆ ON MOUNT MONADNOCK.

BY G. A. WHEELOCK.

Having in the last three years spent many days in studying the striæ on Mt. Monadnock, the writer is unwilling that the results of his observations should be lost for want of record, especially as they seem to have an important bearing upon unsettled questions of surface geology. This mountain is peculiarly favorable to such study. Its long spurs radiating from a central elevation, although less regular than the points of a star, yet present to four points of the compass long ranges of bare rock, which have recorded the markings of the ice period with all their variations of direction, and furnish a lesson not to be found, perhaps, in any other locality.

To understand fully the meaning of the evidence herein detailed, it is necessary to have a clear idea of the relative bearing and position of these radiating ridges or spurs.

For the sake of clearness of description we will suppose the principal ridge, which runs north 25° east, to be straight, and to be four miles long. This ridge was an uplift, sloping toward the west, and presenting its broken and precipitous face toward the east. It is like a dam set obliquely across the current of the northern drift, and its serrated edge rises from fifteen hundred to two thousand feet above the surrounding country, growing higher from each end toward its central parts. If we suppose a section of this range near the centre to be pushed some fifty rods farther west, and elevated to the height of three thousand two hundred and eighty feet, we shall have the summit of Monadnock. A short spur projects west of the summit about a mile, and divides into two branches; these we will call the west and northwest spurs. The two ends of the dam we will call the north and south spurs; these with the western spur and its northwest fork complete the outline of the mountain, making four radii.

Numerous observations of the direction of drift striæ made in the adjoining towns show very general uniformity. They have a range of not more than 15°, varying 15° west of north to north and south. On the summit of Monadnock the direction varies within the same limits. Only one set of striæ were noted there as 5° east of north. So too, following along the northeast spur, there is no change in the striæ so long as the altitude remains the same. The crest is all naked rock for two miles and a half, or three miles, and frequent observations can be made. Just as fast as the ridge falls off in height the striæ gain a more westerly direction, becoming 15°, 20°, 25° west of north; where the rocky ridge terminates and is succeeded by open pastures, 30°, and in many places 40° west, were noted as common. Appearances indicated a local deflection of a current around the northern end of this long dam.

Although a special expedition was made to what I have called the northwest spur, the lower portion of it was so much covered with drift that few exposed places could be found; some five or six however, and all that were noted, showed striæ north 25° east. All the higher portions of the ridge were striated like the summit and the ridge before described.

Another day's expedition was made to the west spur. Standing on the crest of this lofty ridge and looking toward the south, the view is unobstructed to the horizon. The striæ all along this ridge are innumerable and all north and south. There is no opposing ridge near, to lead one to expect south of this a change in the striæ. On the contrary there is every facility for the drift current after passing this ridge to continue on in a straight course. The southern spur is a mile or more off on our left and presents a high opposing barrier toward the southeast but none toward the south. Why should the drift current after passing this ridge, suddenly turn toward the east and climb the steep and lofty barrier of the south spur? Nevertheless there are indications of just such a change as this.

If we place one foot of a pair of imaginary compasses on the summit of Mt. Monadnock, and with the other strike a curve from the west spur to the south spur, we shall hardly have made a more complete change of direction from one spur to the other, than is indicated by the striæ in the short space of a mile and a half. It is difficult to pass over all parts of the valley between these two spurs, the upper portion of it being extremely craggy or uneven. It is better to go down to the open pastures at the base of the mountain. Beginning at the foot of the western spur and skirting the base of the mountain toward the east, the first thing to excite attention is the immense number of bowlders. They exceed in multitude any other deposit about the mountain, but form no part of its talus, which does not fall on this side. They seem to be in some way connected with the change of the drift current, which began at this place, and with the position of the ridge under the lee of which they lie. Passing through these bowlders which continue for half a mile or more, we come to the first bare ledges; these are marked with striæ, N. 20° W. These are soon succeeded by others thirty, forty and fifty degrees west of north. They may not occur all in regular order; on some ledges there are two or three sets of striæ of different angles. Proceeding a mile and a half we arrive at the easterly slope of the south spur near the Mountain House. The road to this house was built north and south on sloping ground, and for half a mile the fresh surface of the rock was in many places exposed to view. It is everywhere scratched and polished. These scratches vary from 50° to 60° and 70° west of north. Climbing the slope of the ridge, everywhere the exposed prominences of rock are embossed in the same direction. Arriving at the crest of the ridge, it is everywhere serrated and uneven.

On this height we again overlook the whole country. Here on the narrow crest of the ridge the striæ are very generally north 40° or 45° west. In one place an angular trough perhaps twenty feet long and six feet deep runs across the crest. In this there are long continuous striæ due east and west. They appear to be exceptional and suggest the idea that this shallow trough had been able to control and change the direction of the striating force. Standing on this ridge and looking toward the east, we see that the mountain on this side is very precipitous, and that probably there are no striæ on its broken surface. Higher up the mountain, within a thousand feet of the summit, the striæ are 35° and 30° west of north; lower down at the extremity of the south spur, the end of the long dam, they vary from 40° to 25° west of north. What kind of striæ should we expect to find under the lee of this four mile breakwater? Another expedition and another day were required to answer this question. The country east of the four mile ridge is mostly wooded and difficult to traverse. The rock is mostly covered with drift. Beginning at the south end and travelling north, no striæ were found until two-thirds of the distance had been passed over. Curiosity was at last gratified by finding large flat surfaces of naked rock scored all over with long parallel lines much better preserved than those on less wooded and more exposed parts of the mountain. It would be difficult to decide what was their prevailing direction. Multitudes ran due east and west; some few north and south; some north 10° west; some north 10° east; many north 70° and 80° west; many north 70° and 80° east. No theory of mountain slides could explain this remarkable scratching; the situation seemed to forbid such an explanation. These observations were made on many different ledges, but all of them within a half mile of each other, and within a mile of the north end of the ridge. When a rapid stream with a current of three miles an hour passes a rock in its bed, water will flow around the rock and meet on its lower side. Do not these irregular striæ indicate a changeable and eddying current inconsistent with the motion of a glacier?

Mt. Monadnock furnishes some suggestions also on the subject of erosion. Chemical agency and the action of frost may properly enough account for a large amount of rock disintegration. On long lines of coast the ceaseless waves of the ocean cause an endless amount of erosion. But the amount of actual planing and grinding of the earth's surface by icebergs or continental glaciers seems somewhat speculative and furnishes small means of measurement. Whoever has had experience in grinding and polishing mineral specimens knows full well that, so long as there are protuberances or cavities on the surface he is grinding, he has accurate means of judging his rate of progress. But when he is grinding a flat surface, he has no means of judging from the surface itself. So here on a large scale, all along these naked mountain ridges there are rounded angles and mammillary protuberances of all dimensions, which are marked with striæ, but have never been ground down to a flat surface. They are rounded, scratched and often polished. Is it not possible to reconstruct the angles and edges that are worn off and thus have an approximate measure of ice erosion? On a hill in Keene there are acres of hard quartz rock lying uncovered and much exposed to glacial action. The rock is composed of laminæ an inch thick, and these incline toward the south. When the rock is fractured obliquely, the fracture is interrupted by each lamina, so that the edges of the laminæ project slightly like the serratures of a file. Now all over these sharp serratures there has been much grinding and polishing, but the shallow cavities originally between them have rarely ly been ground out, and there is no reason for supposing that this hard rock has ever been eroded more than half an inch. On Monadnock, where the rocks have a regular jointed structure and the upper edge alone has been worn off, it is often easy to supply the lost angle, by reproducing the contiguous sides. Studied in this method an erosion of one or two feet would be as much as is indicated on all the higher portions of the mountain. On lower ground surfaces are more flat and judgment is at fault. Between the northwest and northeast spurs a wide valley opens out toward the drift current. This extended valley is filled with mammillated rocky protuberances projecting among the spruces which grow everywhere between them, from six to ten feet high. This valley is in the line of the drift and would be eroded if any place would, but the protuberant rocks seem merely to be rounded and the roughness of original fracture worn off.

A few words about the erratic bowlders in this vicinity may not be irrelevant. There are bowlders here of a phonolitic character, which often contain black porphyritic pebbles fused into their substance, making them very easy of identification. These have been a subject of special study, and some fifty of them have been found in Cheshire county. Prof. Charles H. Hitchcock, who is intimately acquainted with New England rocks, says he has never seen such rocks, in place, anywhere, except in the vicinity of Ascutney, Vt. Ascutney mountain was thrown up in a state of fusion, and its heat melted this conglomerate which lay close by it. Ascutney is about fifty miles from Monadnock and north 10° west. Two of these bowlders lie at the base of the Monadnock. There is one in Keene that must weigh one hundred tons. Many were found near together or in the same line; but many more show a great lateral divergence. Keene is forty miles from Ascutney, and in that distance many bowlders have diverged eight miles, or one mile in five from the starting point. These bowlders have been dug out of the drift at various depths. While it is difficult to imagine a continental glacier making so many and such wide diverging lines, it is also difficult to understand how icebergs could have picked up these bowlders and polished their hard material on so short a journey.